COOLING FIN STRUCTURE AND METHOD OF FORMING SAME

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This invention relates to cooling fins and is particularly directed to a cooling fin structure and to a method of fabricating such fins, said invention constituting an improvement over that disclosed in copending application Serial No. 39,613, filed April 30, 1949, now abandoned.

The cooling fin structure disclosed in said copending application has been applied to the cylinders of an aircraft engine and has performed and is performing in a highly satisfactory manner. This successful operation of said cooling fin structure results from the fact that fabrication of said structure involves no bending or forming of the fins whereby it is possible to make the fins of a material which is sufficiently strong to withstand severe engine vibration.

However, difficulty has been experienced in handling the fin structure of said copending application prior to its securement to the engine cylinders and in securing said fin structure to the engine cylinders. Said prior fin structure comprises a pair of flat fin members between which and along their inner edges an anchoring strip of soft metal is disposed. To facilitate handling and installation, said anchoring strip is welded to the fin members to provide a unitary double fin and anchoring strip assembly. It has been found, however, that said fin members tend to break away from the anchoring strip during handling. It has also been found that said anchoring strip tends to break away from the fin members when pressure is applied thereto for positioning the fin members within an engine cylinder groove prior to the anchoring process and when this happens the anchoring pressure applied to said strip pressure may tend to eject the fin members from said groove.

An object of the present invention comprises the provision of a novel cooling fin structure and method of fabricating same avoiding the aforementioned difficulties of said prior structure and at the same time retaining the advantages and highly satisfactory performance of said prior structure. A further object of the present invention comprises the provision of a novel fin structure and method of securing together a pair of members and anchoring strip to provide an assembly which can be handled as a unit structure. A still further object of the invention comprises the provision of a novel double fin and anchoring strip assembly in which the fin members have tabs or flange means bridging at least a portion of the gap between their inner edges and against which flange means the anchoring strip is disposed. With this struc-

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ture, the pressure applied to the anchoring strip for securing the fin members within a groove not only acts against the fin members to press said members apart against the side walls of said groove but said pressure also acts against said tabs or flange means to help hold the fin members in position against the bottom of the groove.

Other objects of the invention will become apparent upon reading the annexed detailed description in connection with the drawing in which:

Fig. 1 is an axial sectional view of a portion of an engine cylinder having cooling fins embodying the invention;

Fig. 2 is a sectional view taken along line 2—2 of Fig. 1;

Fig. 3 is an enlarged view of a flat fin member at an initial stage of its fabrication;

Fig. 4 is a further enlarged perspective view of a portion of the fin member illustrated in Fig. 3;

Fig. 5 is a view similar to Fig. 4 but illustrating the fin member at a subsequent stage of its fabrication;

Fig. 6 is a perspective view of a portion of a pair of fin members each similar to the fin member illustrated in Fig. 5, said pair of fin members being disposed in spaced side-by-side relation, with an anchoring strip therebetween, in readiness for the next fabrication step;

Fig. 7 is a perspective view of a portion of a completed double fin and anchoring strip assembly ready for attachment within a groove of an engine cylinder or other body to be cooled;

Fig. 8 is a sectional view illustrating the mode of attachment of said double fin and anchoring strip assembly within a groove of a body to be cooled;

Fig. 9 is a development of the double fin assembly of Fig. 7;

Fig. 10 is a development of a modified double fin assembly;

Fig. 11 is a sectional view illustrating a step in the fabrication of the double fin assembly of Fig. 10;

Fig. 12 is a development of another double fin assembly modification; and

Fig. 13 is a sectional view of a completed double fin assembly having the structure of Fig. 12.

Referring first to Figs. 1 and 2 of the drawing, an engine cylinder barrel is illustrated in part at 10, said cylinder having a plurality of axially spaced annular grooves 12 formed in its exterior surface. A semi-circular double fin and anchoring strip unit 14 has its inner semi-circular edge
secured in each of the cylinder grooves 12 and similar semi-circular double fin and anchoring strip units 14 are secured in said grooves on the diametrically opposite side of the cylinder barrel.

Briefly each unit or assembly 14 comprises a pair of spaced fin members 16 which extend from a cylinder groove 12 and an anchoring strip 18 disposed within said groove between said fin members. The anchoring strip 18 presses the adjacent portions of the fin members apart against the side walls of said groove. The details and mode of fabrication of each assembly 14 are illustrated in Figs. 3-7.

Referring now to Figs. 3-7, each fin member 16 is cut or stamped from flat metallic sheet-like material in the form of a semi-circular arc with a notched inner edge. Such a stamped sheet member is designated by reference numeral 15b in Figs. 3 and 4. The notched inner edge of each sheet member forms a series of equally spaced identical tabs 22a alternating with recesses 22b. Said inner edge of the sheet member 15b is notched so that there is a complete tab 22a at one end of said edge and a complete recess 22b at the other end. With this construction two identical sheets 15b can be disposed in side by side relation so that recesses 22b in the one sheet are disposed opposite the tabs 22a of the other sheet by disposing the tab end of the inner edge of said one sheet member 15b opposite the recess end of the inner edge of the other sheet member 15b.

The tabs 22b of each sheet member 15b are now bent or formed along the line 2-2 thereby forming flanges extending at right angles to the flat surface of the sheet member. In this condition (Fig. 5) the sheet member is designated by reference number 15a and the bent tabs by reference number 22a. It should be noted that the line 2-2 passes across each tab at a point relatively close to but spaced from the inner end of each tab thereby leaving a small portion 22a of each recess in the plane of the sheet member.

As illustrated in Fig. 6, two sheet members 15a are now disposed and assembled in side-by-side relation with the tabs 22a of one member passing between the recesses 22b of the tabs 22a of the other member. This is done by disposing the tab end of the inner edge of one of said sheet members opposite the recess end of the inner edge of the other sheet member. A semi-circular strip 15c, preferably of relatively soft metallic material, is disposed between said two sheet members 15a along their notched edges and against the tabs 22a. As hereinafter described the strips 15a are used for anchoring the fins within the cylinder grooves 12.

At this point it should be noted that the recesses 22b of each sheet or fin member 15b should have a width at least as great as the width of the tabs 22b in order to permit assembly of a pair of fin members as illustrated in Fig. 6. Preferably each recess 22b is only slightly wider than the width of the tab 22a so that the tabs 22a are disposed in side-by-side relation thereby forming a substantially continuous surface bridging the space between the two sheet members 15a.

Each tab 22a has a length somewhat greater than the width of the space between the adjacent sheet or fin members 15a so that each tab of one sheet member 15a projects beyond the other or adjacent sheet member (as illustrated in Fig. 6). In the next fabrication step, said projecting portion of each tab 22a is bent around and against the anchoring strip 18a into the adjacent recess 22a (as illustrated in Fig. 7) thereby forming a double fin and anchoring strip assembly 14. The sheet or fin members are now designated by reference number 16 and the tabs by reference number 22a.

The width of the fin members 16 and anchoring strip 18a preferably are such that, after bending the tabs to the condition of Fig. 7, the width of the assembly is slightly greater than that of the groove 12 within which said assembly is to be secured. The assembly 14 is then squeezed together against the relatively soft anchoring strip 18a to the required width to permit insertion within a groove 12. As a result of this squeezing operation, the anchoring strip 18a is securely gripped or clamped in position between the fin members. If desired each tab 22a may be bent so as to dig slightly into the anchoring strip 18a to provide additional gripping action between the fin members and the anchoring strip. With the anchoring strip 18a in position between the tabs 22a of an assembly 14, the fin members 16 of said assembly are positively held together by the tabs 22a.

The inner edge of the double fin member and anchoring strip assembly is now inserted into a groove 12 as best seen in the enlarged view of Fig. 8. A roller or bar 24 is then inserted between the fin members 16 to apply pressure against the anchoring strip 18a. This pressure deforms said strip to the condition illustrated by reference numeral 18a in the lower groove 12 of Fig. 8. Fig. 8 illustrates two cylinder grooves 12 each having a double fin assembly 14 inserted therein but in the upper cylinder groove the assembly 14 is illustrated prior to the application of pressure against the anchoring strip. This pressure forces the strip 18 against the portions of the tabs 22a bridging the bottom of the associated groove 12 and spreads said strip against the adjacent portions of said tabs and fin members thereby pressing said portions against the side walls of said grooves to anchor the assembly 14 in said groove. As illustrated in Fig. 8, the groove 12 may be formed with a slight undercut to increase the gripping action between the fin members 16 and the side walls of said groove 12.

The maximum stress in a fin member 16 resulting from engine vibration occurs along the outer edge of its cylinder barrel groove 12. As illustrated in Fig. 8, the tabs 22a of each fin member are of such length, relative to the dimensions of their cylinder groove 12, that said tabs are disposed entirely within said groove. Preferably, each tab 22a extends less than half way up the side wall of its groove toward the outer edge of said groove from the groove bottom wall. With this construction the tabs 22a do not lessen the ability of the fin members to withstand engine vibration.

The curvature of the line 2-2 along which the tabs 22a of a fin member 16 are to be bent to form the tabs 22a necessarily must be substantially the same as the longitudinal curvature of the bottom of the groove 12 in which tab 22a so that the said fin member is to be disposed. As illustrated in Fig. 3 the line 2-2 is a circular arc and there are thirteen tabs 22a and thirteen recesses 22b in an arc of 180°. Thus each of the tabs 22a is bent along a portion of the line 2-2 constituting an arc of only about 7°. This is in sharp contrast to a practical standpoint each tab is bent along a straight line. This is quite important because fin material having sufficient strength to withstand engine vibration is very difficult to bend or form along a curved line as compared
to bending said material along a straight line. For this reason, the width of each tab should be kept small. Preferably, the width of each tab should be sufficiently small so that the arc length of the groove bottom wall along which said tab is disposed is less than about 15°. Each inter-tab recess 22b has substantially the same width as a tab 20b. Accordingly, if the cylinder groove 12 is a circular arc of N degrees, the fin member 16b to be secured in said groove preferably has at least N/30 tabs 20b.

The width of each tab 20 and inter-tab recess should also be kept small in order that the successive tabs and associated close together whereby any temperature variation along the root of anchored end of each fin member 16 is more gradual than would be the case if said tabs and recesses were substantially wider. In addition, with a large number of tabs of not too great a width, the pressure of the anchoring strip, during the anchoring operation of a double fin assembly, is more uniformly applied by said tabs to the two fin members of said assembly.

Each of the double fin assemblies 14 is substantially semi-circular so that two such assemblies are provided a pair of substantially annular fins projecting from each cylinder barrel groove 12. If desired, however, it is possible merely to secure a double fin unit 16 on only one side of a cylinder barrel. Furthermore the invention is obviously applicable to the engine cylinder head as well as to the engine cylinder barrel. In fact any heat exchange body can be provided with fins in accordance with the invention. Thus it is not necessary that the grooves, in the heat exchange body to which the fins are to be secured, comprise circular arcs. In this connection it is only essential that the general profile of the edge of the double fin assembly to be inserted within a groove be similar to the longitudinal profile of the bottom of said groove.

With the aforesaid method and construction of the double fin assembly 14, the only bending or forming required of the fin material is the bending of the tabs 20. As already stated, these tabs are not very wide compared to the length of the adjacent fin edge so that it is possible to readily bend said tabs even though the fin members are made of strong and hard material. Thus it is possible to make the fin members 16 of the same aluminum alloy used in the construction of said component application, namely of an alloy having a composition defined by Aviation Materials Specification No. 4017. This alloy comprises 2.2 to 2.5% magnesium, 0.15 to 0.35% chromium with the balance aluminum except for possible impurities. This material obviously is only one example of the possible materials which could be used for the fins. If, for example, the body to which the fins are to be applied is not subjected to any vibrations of the magnitude to which an aircraft engine cylinder is subjected, then the fins could be made of a material which although not as strong and hard is even a better heat conductor than the above specified aluminum alloy.

Double fin assemblies 14 of the present invention thereby retain all the advantages of the construction of said component application. At the same time the tabs 20 and anchoring strip 18a of each assembly 14 securely hold said assembly together prior to attachment of said assembly within a groove 12. Thus the assembly 14 can readily be handled as a unit structure thereby facilitating attachment of said assembly to the heat exchange body. In addition, when pressure is applied to the anchoring strip 18a for securing the associated assembly 14 in a groove 12, said pressure is applied directly to the portion of each tab 20 bridging the bottom of said groove thereby holding two fin members 16 in position while the pressure on said strip presses the adjacent portions of the two fin members 16 apart against the side walls of said groove.

As described, each tab 20b is first partly bent to a condition illustrated in Fig. 5 in which said tab extends at right angles from its fin member and in a subsequent step the tab bending is completed by bending each tab into an inter-tab recess 22c to the condition illustrated in Fig. 7. Obviously, however, the step of Fig. 5 may be eliminated by placing a pair of flat fin members 16b in side-by-side relation with an anchoring strip therebetween along their notched edges and then bending their tabs 20d directly to the condition illustrated in Fig. 7.

Fig. 9 is a development of one of the fin assemblies 14a and illustrating the overlapping fit of the tabs 20 together with the two lines x-x along which said tabs are bent. Fig. 9 is illustrated merely to help explain the modified constructions illustrated in Figs. 10-15.

Fig. 10 illustrates a modified construction in which the tabs of one fin member are interlocking fitted within recesses in the other fin member. Fig. 10 is a developed view like Fig. 9 and illustrates a double fin assembly 30 comprising a pair of fin members 32 each having tabs 34 extending into inter-tab recesses 36 in the other fin member. As illustrated each recess 36 has a wide portion adjacent its inner end and within which a wide portion of a tab 34 is dove-tailed or interlockingly received. With this dove-tailed or interlocking construction, when pressure is applied by an anchoring strip to a particular tab 32 of a double fin assembly 30, said pressure not only is transmitted to the fin member of said tab but, because of said dove-tailed construction, is also transmitted by said tab to the other fin member.

With this construction of Fig. 10 it is possible to first partly bend the tabs 34 at right angles to their fin members and then assemble a pair of fin members 32 in a manner similar to the fin member 16a in Fig. 6. However a pair of notched flat fin members 32 may be disposed in side-by-side relation and then each tab of one of said members may be bent into a recess in the other member as already discussed in connection with Figs. 3-7. However if some preliminary bending of the tabs 34 is desired they may initially be bent at some angles less than 90°, as for example 45°, and then a pair of fin members 32 may be disposed in side-by-side relation with an anchoring strip therebetween as illustrated in the sectional view of Fig. 11. Except for said dove-tailed or interlocking tab construction, the double fin assembly 30 is identical with a double fin assembly 14.

Fig. 12 is a developed view similar to Fig. 9 but of a further modified construction. The modification of Fig. 12 has the advantage in that each fin member has a continuous flange along its inner edge against which the anchoring strip pressure is applied, but because of this continuous flange fabrication of this modification is considerably more difficult. Fig. 13 is a sectional view through a double fin and anchoring strip assembly having the construction of Fig. 12.

In Figs. 12 and 13, a double fin and anchoring strip assembly 40 comprises a pair of fin mem-
7 bers 42 each having a continuous flange 44 along its inner edge, that is along its edge to be secured within a groove of a heat exchange body. Each flange 44 has a length so that when assembled in said groove it extends no more than half way across the bottom of said groove. In addition a plurality of tabs 46 extend from each flange 44 into a recess 45 in the other fin member. In this modification only enough tabs 43 need be provided to hold a double fin and anchoring strip assembly together so that said assembly can be handled as a unit structure. For example, three tabs 46 may be sufficient, two tabs on one fin member of the assembly and the other tab on the other fin member. If desired each tab 44 and recess 45 may have the dove-tailed or interlocking construction of Figs. 10 and 11.

While I have described my invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding my invention, that various changes and modifications may be made therein without departing from the spirit or scope of the appended claims to cover all such modifications.

I claim as my invention:

1. The method of providing a body having a groove on its surface with a pair of heat exchange fins projecting from said surface; said method comprising cutting two similar fin members from flat sheet-like material and notching an edge of each fin member so as to form a series of equally spaced alternate tabs and recesses with a tab at one end of said edge and a recess at the other end; forming a double fin member and anchoring strip sub-assembly with said two fin members disposed in spaced side-by-side relation and with an anchoring strip of relatively soft material disposed between said fin members and along their notched edges and with each of the tabs of a fin member being bent part way around and against said anchoring strip into a recess in the other fin member; inserting the anchoring strip edge of said sub-assembly into said groove; and applying pressure against said anchoring strip toward the bottom of said groove so that said strip presses said tabs against the bottom of said groove; Said fin members being spaced apart with their inner edges disposed against opposite side walls of said groove.

2. The method of providing a body having a groove on its surface with a pair of flat heat exchange fins projecting from said surface; said method comprising cutting two similar flat fin members from flat sheet-like material and notching an edge of each fin member so as to form a series of equally spaced alternate tabs and recesses with a tab at one end of said edge and a recess at the other end; bending each tab of a fin member in the same direction at right angles to the plane of said fin member; disposing said fin members in spaced side-by-side relation with the tabs of one fin member extending between the anchoring strip member and projecting beyond said other fin member; disposing an anchoring strip of relatively soft material between said fin members and against said tabs; bending each of said projecting tab portions into a recess in the adjacent fin member and against said anchoring strip to form a double fin member and anchoring strip sub-assembly; inserting the anchoring strip edge of said sub-assembly into said groove; and applying pressure against said anchoring strip toward the bottom of said groove so that said strip presses said tabs against the bottom of said groove and presses the adjacent portions of said fin members against the side walls of said groove to anchor said edge of each fin member to said body in said groove.

3. The method of providing a body having a groove on its surface with a pair of heat exchange fins projecting from said surface; said method comprising cutting two fin members from flat sheet-like material and notching an edge of each fin member so as to form a series of spaced alternate tabs and recesses; forming a double fin member and anchoring strip sub-assembly with said two fin members disposed in spaced side-by-side relation and with an anchoring strip of relatively soft material disposed between said fin members and along their notched edges and with each of the tabs of a fin member being bent part way around and against said anchoring strip into a recess in the other fin member; inserting the anchoring strip edge of said sub-assembly into said groove; and applying pressure against said anchoring strip toward the bottom of said groove so that said strip presses said tabs against the bottom of said groove and presses the adjacent portions of said fin members against the side walls of said groove to anchor said edge of each fin member to said body in said groove.

4. The method of fabricating a double fin member and anchoring strip assembly for securing within a groove of a body in which said groove is curved so as to extend at least part way around said body; said method comprising the steps of cutting two fin members from flat sheet-like material with one edge of each fin member having a curvature similar to that of said curved groove and notching said curved edge of each fin member to form a series of spaced alternate tabs and recesses; disposing said fin members in spaced side-by-side relation with a curved anchoring strip of relatively soft material disposed between said fin members and along their curved notched edges; and bending the tabs of each fin member part way around and against said strip into the recesses in the other fin member.

5. The method of fabricating a double fin member and anchoring strip assembly for securing within a groove of a body in which said groove is curved so as to extend at least part way around said body; said method comprising the steps of cutting two fin members from flat sheet-like material with one edge of each fin member having a curvature similar to that of said curved groove and notching said curved edge of each fin member to form a series of spaced alternate tabs and recesses; disposing said fin members in spaced side-by-side relation with a curved anchoring strip of relatively soft material disposed between said fin members and along their curved notched edges; and bending the tabs of each fin member part way around and against said strip into the recesses in the other fin member such that each said tab terminates against a flat side of said strip intermediate the edges of said flat side.

6. In combination with a body from which heat is to be removed, said body having a groove formed in its exterior surface; a pair of individual metallic fin members each having one edge extending within said groove; said fin members being spaced apart with their inner edges disposed against opposite side walls of said groove,
each of said fin members having flange means extending across the bottom wall of said groove into recess means in the other fin member; and a metallic strip disposed in said groove between said fin members, said strip pressing said flange means against the groove bottom wall and pressing the adjacent portions of said fin members apart against the side walls of said groove and said strip being of relatively soft material compared to the material of said fin members.

7. The combination recited in claim 6 in which said flange means are disposed entirely within said groove.

8. In combination; a body from which heat is to be removed, said body having a groove formed in its exterior surface; a pair of metallic fin members each having one edge extending within said groove, said two fin members being spaced apart with their inner edges disposed against opposite side walls of said groove, each of said fin members having a notched inner edge forming a series of alternate equally spaced tabs and recesses along said edge with a tab at one end of said edge and a recess at the other end and said two fin members being disposed so that the tab end of the inner edge of one fin member is disposed opposite the recess end of the inner edge of the other fin member, each said tab having a length greater than the width of said groove and extending across the bottom wall of said groove and up the adjacent groove side wall into one of said recesses in the other fin member; and a metallic strip disposed in said groove between said fin members, said strip pressing the portions of said tabs extending across said groove bottom wall against said bottom wall and pressing the adjacent portions of said fin members apart against the side walls of said groove and said strip being of relatively soft material compared to the material of said fin members.

9. The combination recited in claim 8 in which each said tab extends no more than half way up a side wall of said groove from the groove bottom wall and said tabs form a substantially continuous surface along the bottom wall of said groove.

10. In combination; a body from which heat is to be removed, said body having a groove formed in its exterior surface with said groove having a longitudinally curved bottom wall; a pair of metallic fin members each having one edge extending within said groove, said two fin members being spaced apart with their inner edges disposed against opposite side walls of said groove from the groove bottom wall and said tabs forming a substantially con-

thinuous surface along the groove bottom wall with each tab having a width which is sufficiently small so that the arc length measured along the groove bottom wall and along which said tab is disposed is less than 15 degrees.

11. In combination; a body from which heat is to be removed, said body having a groove formed in its exterior surface with said groove having a longitudinally curved bottom wall; a pair of metallic fin members each having one edge extending within said groove, said two fin members being spaced apart with their inner edges disposed against opposite side walls of said groove, each of said fin members having a notched inner edge forming a series of alternate equally spaced tabs and recesses along said edge with a tab at one end of said edge and a recess at the other end and said two fin members being disposed so that the tab end of the inner edge of one fin member is disposed opposite the recess end of the inner edge of the other fin member, each of said tabs having a length greater than the width of said groove and extending across the bottom wall of said groove and up the adjacent groove side wall into one of said recesses in the other fin member; and a metallic strip disposed in said groove between said fin members, said strip pressing the portions of said tabs extending across said groove bottom wall against said bottom wall and pressing the adjacent portions of said fin members apart against the side walls of said groove and said strip being of relatively soft material compared to the material of said fin members, each said tab having a width which is sufficiently small so that the arc length measured along the groove bottom wall and along which said tab is disposed is less than 15 degrees.

12. A double fin member and anchoring strip assembly for securing within a groove of a body; said assembly comprising a pair of individual fin members disposed in side-by-side relation and an anchoring strip of relatively soft material disposed between and along one edge of said members, each of said fin members having flange means extending from said edge across the space between said fin members and part way around and against said strip into recess means in the other fin member.

13. A double fin member and anchoring strip assembly for securing within a groove of a body; said assembly comprising a pair of individual fin members disposed in spaced side-by-side relation and an anchoring strip of relatively soft material disposed between and along one edge of said members, said edge of each fin member being notched to form a series of alternate tabs and recesses therealong with a tab at one end of said edge and a recess at the other end and each said tab of a fin member bridging the space between said edges and extending part way around and against said strip into a recess in the other fin member.

14. A double fin member and anchoring strip assembly for securing within a groove of a body; said assembly comprising a pair of individual fin members disposed in spaced side-by-side relation and an anchoring strip of relatively soft material disposed between and along one edge of said members, said edge of each fin member being notched to form a series of alternate tabs and recesses therealong with a tab at one end of said edge and a recess at the other end and each said tab of a fin member bridging the space between said edges and extending part way around and against said strip into a recess in the other fin member.
way around and against said strip into a recess in the other fin member, said tabs forming a substantially continuous surface bridging the space between said fin members.

15. A double fin member and anchoring strip assembly for securement within a groove of a body in which said groove has a longitudinally curved bottom wall; said assembly comprising a pair of individual fin members disposed in side-by-side relation; and an anchoring strip of relatively soft material disposed between and along one edge of said members, said edge of each fin member being notched to form a series of alternate tabs and recesses therelong with a tab at one end of said edge and a recess at the other end and each said tab of a fin member bridging the space between said edges and extending part way around and against said strip into a recess in the other fin member, the profile of the anchoring strip edge of said assembly constituting an arc having a curvature similar to the curvature of the bottom of said groove with each of said tabs having a width which is sufficiently small so that the length of said profile along which said tab is disposed is less than 15 degrees.

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